

# Markscheme

**May 2017**

**Chemistry**

**Higher level**

**Paper 3**

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### Section A

Question			Answers	Notes	Total
1.	a		$\left\langle \frac{0.5}{25.0} \times 100 \right\rangle = 2 \text{ «\%»} \checkmark$		1
1.	b		pipette/pipet «rather than a measuring cylinder» $\checkmark$	Accept using a burette/buret. Accept using a volumetric/measuring flask. Do not accept “use of a more precise measuring cylinder”.	1
2.	a		more «moles/amount» of acid have been added/reacted <b>OR</b> more of the limiting reagent is present <b>OR</b> more «of the exothermic» reaction has occurred $\checkmark$		1
2.	b		no more reaction/same energy released <b>AND</b> cold/colder/cooler liquid added <b>OR</b> no more reaction/same energy released <b>AND</b> greater total volume of liquid $\checkmark$	Accept “no more reaction/same energy released <b>AND</b> greater heat loss «to the surroundings in mixture D»”.	1
3.			volume «found by extrapolation of the two best fit lines» required to give the highest temperature <b>OR</b> extrapolate «two best fit» lines to the point where they meet $\checkmark$	Accept “where lines through the points meet”. Accept “at maximum temperature”. Accept “at 35 cm <sup>3</sup> of HCl”.	1

Question			Answers	Notes	Total
4.			<p>graph would peak/maximum at 17.5 cm<sup>3</sup></p> <p><b>OR</b></p> <p>half/smaller volume of acid «to reach equivalence» ✓</p> <p>sulfuric acid is dibasic/diprotic ✓</p> <p>higher temperature would be reached ✓</p>	<p>Accept “graph would peak at a smaller volume” for M1.</p> <p>Accept “gradient/slope «of graph» is greater/steeper” for M1.</p> <p>Accept “1 mol sulfuric acid neutralizes 2 mol of sodium hydroxide” for M2.</p>	2 max

Question			Answers	Notes	Total
5.	a		<p>heat change/evolved can be calculated from the «maximum» temperature increase and the mass of solution</p> <p><b>OR</b></p> <p><math>q = mc\Delta T</math> ✓</p> <p>heat «evolved» gives the number of moles «of both acid and alkali present when neutralisation occurs»</p> <p><b>OR</b></p> <p><math>n = \frac{q}{\Delta H_{neut}}</math> ✓</p> <p>volume «of acid and the volume of alkali required to just neutralise each other» can be used to calculate the concentration«s of both»</p> <p><b>OR</b></p> <p><math>[\text{NaOH}] = \frac{n}{V}</math> ✓</p>		2 max
5.	b		<p>smaller temperature increase/<math>\Delta T</math></p> <p><b>OR</b></p> <p>heat released would «appear to» be less ✓</p> <p>amount of substance/n «calculated is » smaller ✓</p>		2

5.	c	using «expanded» polystyrene cup <b>OR</b> insulating beaker <b>OR</b> putting a lid on beaker ✓	Accept any other reasonable suggestion. Do not accept “calorimeter” by itself.	1
5.	d	«specific» heat capacity of the beaker/container/thermometer is ignored <b>OR</b> density of the solutions is assumed as $1.00 \text{ g cm}^{-3}$ /same as water <b>OR</b> specific heat capacity of the solutions is assumed as $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ /same as water ✓	Accept “reaction goes to completion”. Accept “reaction is conducted under standard conditions”. Accept “no evaporation occurs”. Accept any other relevant valid assumption. Do <b>not</b> accept “heat is not released from other reactions”.	1
5.	e	allows simple theories to be applied to real life situations <b>OR</b> enables us to start to understand complex situations <b>OR</b> gives answers that are accurate to the required order of magnitude <b>OR</b> simplifies the calculations involved ✓	Accept “errors do not have a major impact on the results”. Do <b>not</b> accept “to simplify the situation” without further detail.	1
5.	f	temperature rise would be too small «to be accurately measured» ✓	Accept “heat released would be too small «to be accurately measured»”.	1

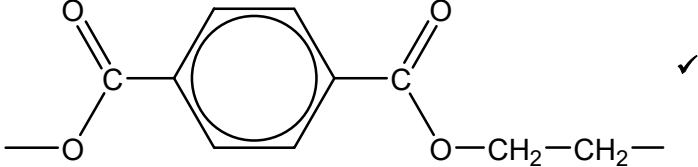
## Section B

### Option A — Materials

Question			Answers	Notes	Total
6.	a		polar covalent ✓ average electronegativity $\llcorner = \frac{1}{2} (3.0 + 2.0) \llcorner = 2.5$ <b>AND</b> electronegativity difference $\llcorner = 3.0 - 2.0 \llcorner = 1.0$ ✓		2
6.	b		ionic bonding <b>OR</b> electrostatic forces between ions ✓  «slight» movement brings ions of same charge adjacent to each other «causing the crystal to break» <b>OR</b> «slight» movement results in repulsion between layers «causing the crystal to break» ✓		2
7.	a		too high/higher than carbon in the reactivity series <b>OR</b> carbon/C is a weaker reducing agent than lanthanum/La ✓	Accept “lanthanum is more reactive than carbon”. Accept “lanthanum is a weaker oxidizing agent than carbon”. Accept converse arguments.	1
7.	b		amount of La $\llcorner = \frac{1000\text{g}}{138.91\text{gmol}^{-1}} \llcorner = 7.20 \llcorner \text{mol} \llcorner$ ✓ $Q \llcorner = 7.20 \text{ mol} \times 3 \times 96\,500 \text{ C mol}^{-1} \llcorner = 2.08 \times 10^6 \llcorner \text{C} \llcorner$ ✓ $I \llcorner = \frac{2.08 \times 10^6 \text{ C}}{60 \times 60\text{s}} \llcorner = 579 \llcorner \text{A} \llcorner$ ✓	Award [3] for “578 «A»” (from premature rounding) or “579 «A»”.	3

Question			Answers	Notes	Total
8.	a		twelve/12 ✓		1
8.	b		«moving» electron attracts «nearby» positive charges/ions/cations ✓ creates «local» regions of increased positive charge ✓ positive charge/field attracts second electron «with opposite spin» ✓ two electrons form a Cooper pair ✓ «all» Cooper pairs «in sample» interact/form «electron» condensate ✓ «electron» condensate/Cooper pairs move/flow «through sample» freely/without resistance ✓		3 max
8.	c		reduces the band gap to zero <b>OR</b> «at high temperatures» thermal motion disrupts the formation of Cooper pairs ✓		1

9.	a		Repeating unit:  Other product: water/H <sub>2</sub> O ✓	Continuation bonds necessary for the mark. Accept alternative repeating unit with O at other end. Do <b>not</b> penalize square brackets or n.	2
9.	b		condensation ✓	Accept polyester or thermoplastic.	1
9.	c		combine with reactants to form «a temporary» activated complex/intermediate <b>OR</b> consumed in one reaction/step <b>AND</b> regenerated in a later reaction/step ✓		1
9.	d		can modify/improve the catalyst/reaction «by making logical predictions» <b>OR</b> science relies on models to understand physical reality ✓	Accept other reasonable, relevant answers. Accept “to predict/select the ideal catalyst for a reaction”.	1

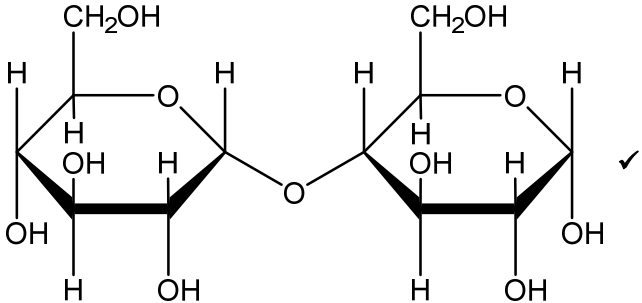
Question			Answers	Notes	Total
10.	a		electrons <b>AND</b> positive ions «in gaseous state» ✓ high frequency/alternating current passed through argon <b>OR</b> «oscillating» electromagnetic/magnetic field <b>OR</b> high frequency radiowaves ✓	Accept “gas” instead of “argon”.	2
10.	b		$K_{sp} = [\text{Sb}^{3+}]^2 \cdot [\text{S}^{2-}]^3$ ✓ $[\text{Sb}^{3+}]^2 \cdot (10^{-14})^3 = 1.6 \times 10^{-93}$ ✓ $[\text{Sb}^{3+}] \ll \sqrt{1.6 \times 10^{-51}} \gg = 4.0 \times 10^{-26} \text{ «mol dm}^{-3}\text{»}$ ✓	Award [3] for correct final answer.	3
10.	c		EDTA/ethylenediaminetetraacetic acid <b>OR</b> $\text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{HN}_2$ /ethane-1,2-diamine ✓	Accept “EDTA <sup>4-</sup> ”. Accept other chelating agents.	1



Question			Answers	Notes	Total
11.	a		<p><i>A RIC: 1 AND B RIC: 4 ✓</i></p> <p><b>ALTERNATIVE 1:</b> «only» PETE contains carbonyl/C=O/ester/COO groups ✓ carbonyl groups absorb at 1700–1750 «cm<sup>-1</sup>» ✓</p> <p><b>ALTERNATIVE 2:</b> LDPE contains more C–H bonds «than PETE» ✓ C–H bonds absorb at 2850–3090 «cm<sup>-1</sup>» ✓</p>	<p><i>For either, accept specific frequencies in these ranges (eg 1735 «cm<sup>-1</sup>» or 2900 «cm<sup>-1</sup>»).</i></p>	3
11.	b	i	<p>HDPE less branched <b>OR</b> LDPE more branched ✓</p>	<p><i>Accept “no branching in HDPE AND branching in LDPE”.</i></p>	1
11.	b	ii	<p>HDPE «polymer» chains/molecules can pack together more closely «than LDPE chains» <b>OR</b> HDPE «polymer» chains/molecules have a higher contact surface area «than LDPE chains» ✓</p> <p>stronger intermolecular/dispersion/London/van der Waals’ forces in HDPE <b>AND</b> higher melting point ✓</p>	<p><i>Accept converse arguments.</i></p>	2

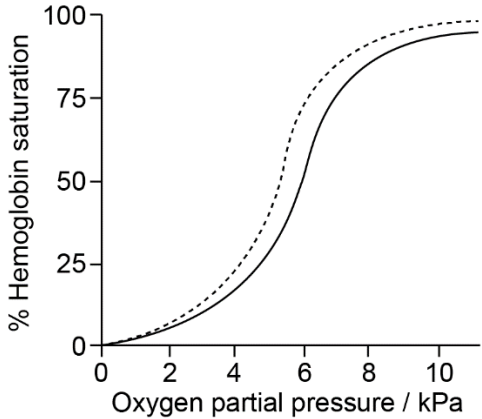
Option B — Biochemistry

Question			Answers	Notes	Total
12.	a	i	<p>«water/aqueous solubility depends on forming many» H-bonds with water ✓</p> <p>raffinose has many hydroxyl/O–H/oxygen atoms/O «and forms many H-bonds»  <b>AND</b> linoleic acid has few/one hydroxyl/O–H/oxygen atom/O/carboxyl group/                      COOH/is largely non-polar «and cannot form many H-bonds» ✓</p>	Accept statement which implies comparison.	2
12.	a	ii	<p>«base» hydrolysis/saponification  <b>OR</b>                      «produces glycerol and» soap/salt of the «fatty» acid ✓</p> $  \begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{O}-\text{C}(=\text{O})-\text{R} \\   \\ \text{H}-\text{C}-\text{O}-\text{C}(=\text{O})-\text{R} \\   \\ \text{H}-\text{C}-\text{O}-\text{C}(=\text{O})-\text{R} \\   \\ \text{H} \end{array} + 3\text{NaOH} \longrightarrow \begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{OH} \\   \\ \text{H}-\text{C}-\text{OH} \\   \\ \text{H}-\text{C}-\text{OH} \\   \\ \text{H} \end{array} + 3(\text{R}-\text{COO}^- \text{Na}^+) \checkmark  $ <p>«products are» water soluble «and drain away» ✓</p>	Accept condensed formulas. Accept non-balanced equation. Accept “RCOONa”.	2 max
12.	b		<p>linoleic acid/C<sub>18</sub>H<sub>32</sub>O<sub>2</sub> combustion/oxidation more exothermic «per mol» ✓</p> <p>linoleic acid/C<sub>18</sub>H<sub>32</sub>O<sub>2</sub> has lower proportion/number of O atoms  <b>OR</b>                      linoleic acid/C<sub>18</sub>H<sub>32</sub>O<sub>2</sub> is less oxidized ✓</p>	Accept converse arguments.	2

Question			Answers	Notes	Total
13.	a	i	$  \begin{array}{c}  \text{CHO} \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{H} - \text{C} - \text{OH} \checkmark \\    \\  \text{H} - \text{C} - \text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $	<p>All OH groups must be on the same side.</p> <p>Accept structures with chiral carbon atoms shown as C or C* instead of crosses.</p>	1
13.	a	ii		<p>Accept –O– in a straight line provided both Hs are above the plane.</p>	1
13.	b		<p>«allow» 3-D perspective of structures «of cyclic monosaccharide molecules»  <b>OR</b>            «show» <i>cis</i>/same side arrangement of «attached» groups  <b>OR</b>            «show» <i>trans</i>/opposite side arrangement of «attached» groups  <b>OR</b>            «make» carbon and hydrogen implicit ✓</p>		1
13.	c	i	<p>abundant/renewable/allows use of «local» vegetation  <b>OR</b>            less use of fossil fuel/oil based plastics  <b>OR</b>            air permeable/better breathing of products  <b>OR</b>            «can be» mixed/blended with synthetic polymers ✓</p>	<p>Do <b>not</b> accept answers related to biodegradable examples.</p> <p>Ignore any reference to cost.</p> <p>Accept “carbon neutral/do not contribute to global warming”.</p> <p>Accept “require less energy to produce”.</p> <p>Accept “do not produce toxic products”.</p>	1
13.	c	ii	<p>HO–CH(CH<sub>3</sub>)–COOH/CH<sub>3</sub>CH(OH)COOH ✓</p>	<p>Do <b>not</b> accept C<sub>3</sub>H<sub>6</sub>O<sub>3</sub>.</p> <p>Do <b>not</b> accept OH-CH(CH<sub>3</sub>)-COOH.</p>	1



Question			Answers	Notes	Total
15.	a		«pH range» 8.6–10.6 ✓	<i>Accept any value between 8.2 and 11.0.</i>	1
15.	b		« $K_m$ =» 0.67 «mmol dm <sup>-3</sup> » ✓	<i>Do not penalize if a graph is drawn to determine the value.</i>	1
15.	c		does not compete for active site <b>OR</b> binds to allosteric site/away from «enzyme» active site <b>OR</b> alters shape of enzyme ✓  reduces rate/ $V_{max}$ ✓		2
15.	d		«% cytosine + % guanine = 100 % – 17 % – 17 % = 66 %» Cytosine: 33 «%» <b>AND</b> Guanine: 33 «%» ✓ Thymine: 17 «%» ✓		2

Question			Answers	Notes	Total
16.	a		binding of O <sub>2</sub> «to one active site» affects shape of Hb/other active sites <b>OR</b> binding of one O <sub>2</sub> «molecule» affects binding of other O <sub>2</sub> «molecules» ✓  increasing affinity of Hb to O <sub>2</sub> <b>OR</b> enhanced binding of «further» O <sub>2</sub> «molecules» <b>OR</b> cooperative binding ✓		2
16.	b	i	 <p>sketching right shift of curve on graph ✓</p>		1
16.	b	ii	decreases «oxygen saturation» ✓	Accept “hemoglobin binds to O <sub>2</sub> with less affinity”.	1
17.			11- <i>trans</i> retinal no longer fits into the rhodopsin/protein <b>OR</b> 11- <i>trans</i> retinal is ejected from the rhodopsin/protein ✓  leads to conformational change in rhodopsin/protein «to opsin generating signals» ✓		2

Option C — Energy

Question			Answers	Notes	Total
18.	a		presence of dark/absorption lines corresponding to those found for carbon <b>OR</b> missing wavelengths/frequencies corresponding to carbon's spectrum ✓	Accept "presence of characteristic dark lines". Do <b>not</b> accept responses in terms of emission spectra.	1
18.	b	i	${}^8_4\text{Be}$ ✓		1
18.	b	ii	loss in mass = «8.005305 amu + 4.002603 amu – 12.000000 amu =» 0.007908 «amu» ✓ = «0.007908 amu × 1.66 × 10 <sup>-27</sup> kg amu <sup>-1</sup> =» 1.313 × 10 <sup>-29</sup> «kg» ✓ E = «mc <sup>2</sup> = 1.313 × 10 <sup>-29</sup> kg × (3.00 × 10 <sup>8</sup> m s <sup>-1</sup> ) <sup>2</sup> =» 1.18 × 10 <sup>-12</sup> «J» ✓	Award [3] for correct final answer.	3
18.	c		fuel more abundant/cheaper ✓ no «long half-life» radioisotopes/radioactive waste ✓ shipment of radioactive fuels not required ✓ plutonium/nuclear weapons cannot be produced from products ✓ nuclear disasters less likely «as no critical mass of fuel required» ✓ higher specific energy/energy per g/kg/unit mass than fission ✓	Do <b>not</b> accept simply "fusion produces more energy than fission".	2 max
19.	a		delocalized bonding/conjugated bonds ✓ contain metal atom/ion coordinated to «organic» ligand(s) ✓ involve bonds from nitrogen to the central metal ion ✓		2 max
19.	b		$\text{I}_3^- + 2\text{e}^- \rightarrow 3\text{I}^-$ ✓	Accept $\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-$ .	1

Question			Answers	Notes	Total
20.	a		methanol <b>OR</b> ethanol ✓  strong acid <b>OR</b> strong base ✓	Accept alcohol.  Accept any specific strong acid or strong base other than HNO <sub>3</sub> /nitric acid.	2
20.	b		CH <sub>3</sub> (CH <sub>2</sub> ) <sub>16</sub> COOCH <sub>3</sub> / CH <sub>3</sub> OCO(CH <sub>2</sub> ) <sub>16</sub> CH <sub>3</sub> <b>OR</b> CH <sub>3</sub> (CH <sub>2</sub> ) <sub>16</sub> COOC <sub>2</sub> H <sub>5</sub> / C <sub>2</sub> H <sub>5</sub> OCO(CH <sub>2</sub> ) <sub>16</sub> CH <sub>3</sub> ✓	Product <b>must</b> correspond to alcohol chosen in (a), but award mark for either structure if neither given for (a).	1
20.	c		Specific energy « = $\frac{12000 \text{ kJ mol}^{-1}}{299 \text{ g mol}^{-1}}$ » = 40.1 «kJ g <sup>-1</sup> » ✓  Energy density « = 40.1 kJ g <sup>-1</sup> × 0.850 g cm <sup>-3</sup> » = 34.1 «kJ cm <sup>-3</sup> » ✓	Award [1] if both are in terms of a unit other than kJ (such as J or MJ).	2

21.	a		heat/react with «oxygen and» water/steam ✓ C + H <sub>2</sub> O → CO + H <sub>2</sub> <b>OR</b> 3C + O <sub>2</sub> + H <sub>2</sub> O → H <sub>2</sub> + 3CO <b>OR</b> 2C + O <sub>2</sub> → 2CO <b>AND</b> C + H <sub>2</sub> O → H <sub>2</sub> + CO <b>OR</b> C + O <sub>2</sub> → CO <sub>2</sub> <b>AND</b> C + CO <sub>2</sub> → 2CO <b>AND</b> C + H <sub>2</sub> O → H <sub>2</sub> + CO ✓	M1 requires concept of heat.	2
21.	b		«Fischer-Tropsch» catalytic reduction of carbon monoxide with hydrogen <b>OR</b> (2n+1) H <sub>2</sub> + n CO → C <sub>n</sub> H <sub>(2n+2)</sub> + n H <sub>2</sub> O <b>OR</b> reduction of carbon monoxide to methanol and catalytic dehydration <b>OR</b> 2H <sub>2</sub> + CO → CH <sub>3</sub> OH <b>AND</b> n CH <sub>3</sub> OH → C <sub>n</sub> H <sub>2n</sub> + n H <sub>2</sub> O ✓	If equation is given for a specific alkane or alkene, it must be a liquid (n>4).	1



Question			Answers	Notes	Total
22.	a		<p><i>Anode:</i> <math>\text{CH}_3\text{OH (aq)} + \text{H}_2\text{O (l)} \rightarrow \text{CO}_2 \text{(aq)} + 6\text{H}^+ \text{(aq)} + 6\text{e}^- \checkmark</math></p> <p><i>Cathode:</i> <math>\text{O}_2 \text{(aq)} + 4\text{H}^+ \text{(aq)} + 4\text{e}^- \rightarrow 2\text{H}_2\text{O (l)} \checkmark</math></p> <p><i>Overall:</i> <math>2\text{CH}_3\text{OH (aq)} + 3\text{O}_2 \text{(g)} \rightarrow 2\text{CO}_2 \text{(aq)} + 4\text{H}_2\text{O (l)} \checkmark</math></p>	<p><i>Accept correctly balanced equations with multiples of the coefficients given here.</i></p> <p><i>Accept reversible or non-reversible arrows for all.</i></p>	3
22.	b	i	<p>«portable» sources of electrical energy/electricity</p> <p><b>OR</b></p> <p>convert chemical «potential» energy to electrical energy/electricity <math>\checkmark</math></p>		1
22.	b	ii	<p>primary cells involve irreversible reactions <b>AND</b> rechargeable cells involve reversible reactions <math>\checkmark</math></p>	<p><i>Accept “primary cells have a limited life before going ‘flat’ AND rechargeable cells can be recharged when ‘flat’”.</i></p>	1
22.	c		<p><i>Voltage:</i></p> <p>chemical nature of electrodes</p> <p><b>OR</b></p> <p>electrode reactions <math>\checkmark</math></p> <p><i>Current:</i></p> <p>diffusion rate</p> <p><b>OR</b></p> <p>internal resistance/resistance of the cell <math>\checkmark</math></p>	<p><i>Accept temperature for either but not both.</i></p> <p><i>Accept concentration for either but not both.</i></p> <p><i>Accept pH for either but not both.</i></p> <p><i>Accept the current depends on the area/separation of the electrodes.</i></p>	2

Question			Answers	Notes	Total
23.	a		<p>computers can now carry out more complex calculations  <b>OR</b>                      better understanding of the interactions between the various systems involved  <b>OR</b>                      clear evidence of global warming  <b>OR</b>                      «reliable» global temperature data now available  <b>OR</b>                      techniques have been available to monitor carbon dioxide levels ✓</p>	<p>Accept “better/faster computers”.                      Accept “better modelling”.                      Accept “better/more reliable/consistent data”.                      Accept “better measuring techniques”.                      Accept other scientifically based (not politically based) reasons.                      Accept if specific relevant data is given.</p> <p>Do <b>not</b> accept “increased combustion of fossil fuels” or “increased concerns about global warming”.</p>	1
23.	b		<p>symmetric stretching will not absorb IR  <b>OR</b>                      asymmetric stretching will absorb IR ✓                      change in polarity/dipole «moment» required «to absorb IR» ✓</p>		2
23.	c		<p><math>\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})</math> «and pH decreases»  <b>OR</b>  <math>\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq})</math> <b>AND</b> <math>\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})</math>                      «and pH decreases» ✓</p>	<p>Accept reversible or non-reversible arrows for all.</p>	1
23.	d		<p>reduce it <b>AND</b> absorbing/reflecting sunlight ✓</p>	<p>Accept “reduce it because of global dimming”.                      Accept “reduce it <b>AND</b> blocking sunlight”.</p>	1

Option D — Medicinal chemistry

Question			Answers	Notes	Total
24.	a		<p>«measures» therapeutic window/margin «of a drug»  <b>OR</b>                      range of doses that produce a therapeutic effect without causing toxic effects ✓</p>	<p>Accept “difference between <math>ED_{50}</math>/minimum effective/therapeutic dose «for 50 % of population» <b>AND</b> <math>TD_{50}</math>/toxic dose «for 50 % of population»”.                      Do <b>not</b> accept “therapeutic index”.                      Do <b>not</b> accept lethal/fatal dose as this is not <math>LD_{50}</math>.</p>	1
24.	b		<p>work directly on <u>opioid/pain</u> receptors «in brain» ✓                      suppress pain impulses in brain/CNS ✓</p> <p>resemble endorphins/enkephalins/natural chemical painkillers «produced in the brain and spinal cord» ✓</p>	<p>Do <b>not</b> award mark for “resemble hormones”.</p>	2 max

Question			Answers	Notes	Total
25.	a		<p>presence of «large» benzene/arene ring <b>AND</b> non-polar/hydrophobic  <b>OR</b>                      presence of «large» benzene/arene ring <b>AND</b> cannot form H-bond with water ✓</p> <p>contain –COOH/carboxyl/–OH/hydroxyl «and ester group» <b>AND</b>                      polar/hydrophilic  <b>OR</b>                      contain –COOH/carboxyl/–OH/hydroxyl «and ester group» <b>AND</b> can form H-bonds with water ✓</p>	<p>Accept “phenyl” for “benzene ring”.</p> <p>Accept “carboxylic acid” for “carboxyl”.</p> <p>Do <b>not</b> accept “alcohol” for hydroxyl”.</p>	2
25.	b		<p>«student’s» sample impure ✓</p> <p>crystal lattice disrupted/not uniform «due to presence of impurities»  <b>OR</b>                      fewer interparticle/intermolecular forces «due to presence of impurities» ✓</p>	Accept converse statements.	2
25.	c		<p><i>One similarity:</i>                      peak at 2500–3000 «cm<sup>–1</sup>»/ peak due to O–H/hydroxyl in carboxylic acids  <b>OR</b>                      peak at 1700–1750 «cm<sup>–1</sup>»/ peak due to C=O/carbonyl  <b>OR</b>                      peak at 2850–3090 «cm<sup>–1</sup>»/ peak due to C–H of arene ✓</p> <p><i>One difference:</i>                      peak at 3200–3600 «cm<sup>–1</sup>» in salicylic acid/ peak due to O–H in phenol in salicylic acid  <b>OR</b>                      «two» peaks at 1700–1750 «cm<sup>–1</sup>» in aspirin <b>AND</b> one peak «in the same area» in salicylic acid ✓</p>	<p>Accept peak at 1600 cm<sup>–1</sup> for arene/ benzene ring – not in the data booklet.</p> <p>Accept “2500–3600 cm<sup>–1</sup> «overlapping absorptions of two O–H» in salicylic acid”.</p> <p>Accept “stronger/broader/split peak at 1700–1750 cm<sup>–1</sup> in aspirin”.</p>	2
25.	d		<p>dissolve compounds in an organic solvent ✓</p> <p>add NaOH(aq)/OH<sup>–</sup>(aq) «to the mixture» to convert aspirin to its water soluble salt ✓</p> <p>separate the two «immiscible» layers ✓</p> <p>convert salt «in aqueous layer» back to aspirin by reacting with acid/H<sup>+</sup> ✓</p> <p>«evaporate solvents and dry»</p>	<p>Accept organic solvents immiscible with water such as hexane, ethyl ethanoate, butyl acetate.</p> <p>Accept any other base.</p> <p>Need explanation for mark.</p>	3 max

25.	e	<p>«use of» alternative solvents such as supercritical/liquid CO<sub>2</sub>  <b>OR</b>                      use of water «as solvent»  <b>OR</b>                      solvent-free reactions «for example, polymerization of propene»  <b>OR</b>                      solid-state chemistry  <b>OR</b>                      recycle «waste» solvents  <b>OR</b>                      catalysis that leads to better/higher yield  <b>OR</b>                      reducing number of steps ✓</p>	<p><i>Do <b>not</b> accept political/regulatory solutions.</i></p> <p><i>“catalysis” not sufficient for mark.</i></p>	1
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Question			Answers	Notes	Total
26.	a		$\text{«pH} = \text{pK}_a + \log_{10} \left( \frac{[\text{HCO}_3^-]}{[\text{CO}_2]} \right) = 6.34 + \log_{10}(11.2) = 6.34 + 1.05 \text{»} = 7.39 \checkmark$		1
26.	b		<p>H<sup>+</sup> from aspirin reacts with HCO<sub>3</sub><sup>-</sup> to form CO<sub>2</sub> and H<sub>2</sub>O</p> <p><b>OR</b></p> <p>H<sup>+</sup> (aq) + HCO<sub>3</sub><sup>-</sup> (aq) ⇌ CO<sub>2</sub> (aq) + H<sub>2</sub>O (l)</p> <p><b>OR</b></p> <p>reverse reaction favoured «to use up some of the H<sup>+</sup> added» ✓</p> <p>pH decreases ✓</p>	<p>No mark for “stating aspirin is a weak acid that dissociates partially to produce H<sup>+</sup>” without reference to reaction with HCO<sub>3</sub><sup>-</sup> or to the equation.</p> <p>Reversible arrows not required for the mark.</p> <p>Do <b>not</b> accept “small pH change when small amount of H<sup>+</sup> is added”.</p>	2

Question			Answers	Notes	Total
27.	a		«drug» blocks/inhibits «viral» enzyme/neuraminidase/NA «activity» ✓ prevents virus from leaving/escaping host cells «thus cannot infect other cells» ✓		2
27.	b		<b>ALTERNATIVE 1:</b> «using» genetically modified/GM <i>E. Coli</i> /bacteria/microorganisms ✓  <i>E. Coli</i> /bacteria biosynthesis <b>OR</b> <i>E. Coli</i> /bacteria «overfed by glucose» undergo fermentation <b>OR</b> cells of the bacteria «are broken down to» form precursor/shikimic acid ✓  <b>ALTERNATIVE 2:</b> use readily available cyclic ester/lactone ✓ forms «the correct stereoisomer of oseltamivir» in a shorter number of chemical steps ✓	Do <b>not</b> accept “planting more Chinese star anise” or other plant sources of shikimic acid.	2
27.	c		«can develop antibiotic» resistance in <u>bacteria/microorganisms</u> <b>OR</b> changes in <u>microbial/bacterial</u> population ✓	Accept secondary effects, such as reduced biodiversity of aquatic/soil ecosystems, denitrification of soil (due to decline in nitrogen-fixing bacteria). No mark for just stating “water contamination”. No mark for just stating “failure of aquatic/marine environment”.	1

Question			Answers	Notes	Total
28.	a		plane of polarization is rotated ✓	<i>Award zero if answer refers to plane-polarized light being bent.</i>	1
28.	b		not a racemic mixture <b>OR</b> two enantiomers not equimolar <b>OR</b> mixture contains optically active impurity <b>OR</b> relative proportions of enantiomers in mixture can be determined ✓		1



